## SEVERE LOCAL HAIL AND WIND STORMS, DECEMBER, 1926

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

| Place | Date | Time | Width of path, yards | Loss of life | Value of property destroyed | Character of storm | Remarks | Authority |
|---|---|---|---|---|---|---|---|---|
| Washington (western part of). | 1 | | | | | Severe wind | Thousands of dollars damage to plate-glass windows and roofs; telegraph, telephone, and transmission wires also damaged to some extent. | Times (Seattle, Wash.); official, U. S. Weather Bureau. |
| Eastport, Me., and vicinity. | 5–6 | | | | | Wind and snow | Traffic impeded | Official, U. S. Weather Bureau. |
| Iowa (northern part of) | 7 | | | | | do | Railway traffic interrupted, and highways blocked by drifts. | Do. |
| California (southern part of) | 8–9 | | | | | Wind and rain | A considerable amount of citrus fruits whipped from trees in some sections; trees injured by twisting and breaking of limbs; barge sunk by sudden squall in San Pablo Bay. | Do. Do. |
| Devils Lake, N. Dak., and vicinity. | 9–10 | | | | | Wind and snow | All highways blocked to motor traffic by drifts | Do. |
| Iowa (northern part of) | 13 | | | | | do | Rail traffic delayed; highways obstructed | Do. |
| Buffalo, N. Y. | 16 | | | 1 | | Gale and snow | Traffic considerably delayed; one death due to exposure. | |
| Iowa (northern part of) | 23 | | | | | Wind and snow | Railway traffic delayed; roads blocked | Do. |
| Havre, Mont. | 24 | | | | | Wind | Insecure signs, awnings, and chimneys blown down. | Do. |

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## STORMS AND WEATHER WARNINGS

### WASHINGTON FORECAST DISTRICT

On December 5 storm warnings were ordered from Delaware Breakwater to Eastport, Me., for strong east winds accompanied by snow, which occurred as indicated. Warnings were changed to northwest the following day.

Storm warnings were ordered displayed the night of the 13th from Wilmington, N. C., to Eastport, in connection with a disturbance of marked intensity over Ontario. Warnings were ordered down south of Delaware Breakwater on the morning of the 14th and winds did not exceed fresh to strong north of Delaware Breakwater.

Small craft warnings were issued the morning of the 15th between Hatteras and Sandy Hook.

On the evening of the 25th, warnings were ordered from Delaware Breakwater to Eastport in connection with a disturbance over Kentucky, and strong winds and gales occurred as indicated.

Storm signals were ordered on the morning of the 28th from Norfolk to Eastport in connection with a disturbance over Mississippi of increasing intensity. This disturbance moved northeastward attended by strong winds and gales over the region indicated in the advices. Small-craft warnings were displayed on the east Gulf coast on the 28th.

Frost or freezing temperature warnings were issued for portions of the east Gulf and south Atlantic States on the 1st, 12th, 13th, 14th, 15th, 16th, 17th, 24th, 29th, and 30th.

Cold-wave warnings were ordered for limited areas several times during the month, but the changes were moderate in all cases and on two occasions delayed. No important cold waves occurred.—*R. H. Weightman.*

### CHICAGO FORECAST DISTRICT

December, 1926, in the Chicago forecast district was colder than usual, especially in the northern quarter, where the mean temperature ranged from about 4 to 8 degrees below normal. As to precipitation, less than the normal amounts occurred, as a rule, but the number of days with a trace or more of precipitation was comparatively large.

*Storms on the Great Lakes.*—The storm warning season continued until the termination of the 15th. During this period several disturbances affected the Great Lakes, but none was of much severity. However, either small craft or storm warnings were issued for all but one of these disturbances. The exception was the disturbance of the 7th–8th, which exhibited only minor force as it crossed the Lakes. The most important storm of the month was that of the 11th–14th. This was a deep disturbance from the northwest and it preceded a severe cold wave. Strong winds or gales occurred over most of the Great Lakes region in this connection. The warnings issued were general in scope and proved timely.

After the close of the storm-warning season, advisory warnings were issued on three occasions for interests on Lake Michigan, where navigation proceeds throughout the year as a rule.

The abnormally cold weather that prevailed at the beginning of the month resulted in a great accumulation of ice in the canals and locks at the "Soo," with the result that one of the earliest and greatest blockades ever experienced in the marine history of the Great Lakes existed for a few days at that time. More than 100 vessels of various kinds were held in the ice.

*Cold waves.*—Cold-wave warnings were issued for some part of the district on 11 dates, although in a few cases the warnings of one date were merely repetitions of those of the previous date. The most severe and widespread cold wave of the month covered the 12th–14th. It swept virtually the entire district. In some instances the 24-hour fall in temperature equaled or slightly exceeded 50 degrees. A second general and marked fall in temperature crossed the district from the 23d to the 25th, but in some areas the minimum temperature required to constitute a cold wave was not reached. Cold waves without warnings occurred in a number of instances, but over limited areas as a rule. In most of these cases the cold wave was of the "radiation" type. That is to say, the fall in temperature occurred over a snow-covered surface in or near the center of a high pressure area.

*Livestock warnings.*—Advices for the benefit of livestock interests were disseminated on the 12th for South Dakota, Nebraska, and Kansas, and on the 22d, for the Dakotas and western Nebraska.—*C. A. Donnel.*

### NEW ORLEANS FORECAST DISTRICT

Storms were not intense and only one cold wave required general warnings.

Northwest storm warnings were issued for the Texas coast in the morning of the 24th and verifying velocities

occurred on the east coast of Texas during the night of the 24th–25th.

On account of the customary early morning departure of fishermen from Corpus Christi, night advices for the benefit of small craft have been inaugurated for that locality and on the 12th and 23d advices based on the p. m. weather charts for "northers" beginning the following day were sent to Corpus Christi. Small craft warnings were displayed on the Texas coast on the 13th and on the Louisiana coast on the 28th.

Cold-wave warnings were issued for Oklahoma and northern Arkansas on the 3d but failed of verification because of the eastward movement of the large area of high pressure central over Saskatchewan Province in the morning of the 3d.

On the 12th a large area of low pressure, in the form of a crescent trough, was being forced rapidly southeastward in advance of a large area of high pressure over western Canada and northwestern United States. Cold-wave warnings were issued for the northwestern half of the district in the morning of the 12th and extended to the Texas coast at night and to the Louisiana coast the next morning.

The cold wave occurred as forecast except that in coast sections the fall in temperature was more gradual than it was elsewhere.

A moderate cold wave, for which timely warnings were issued, overspread the northern portion of the district on the 24th–25th.

Livestock warnings were issued for all severe conditions, mainly in connection with the cold-wave warnings.

Frost or freezing warnings for the coast sections were issued on the 13th, 14th, 15th, 16th, 24th, 25th, 28th, 29th, 30th, and 31st, and conditions generally occurred as forecast.

Fire-weather warnings for winds and weather increasing the fire hazard were issued for forested areas in Oklahoma on the 2d and 11th and in Arkansas on the 11th.

A warning of strong northerly winds reaching gale force at Tampico, Mexico, was issued on the 15th.—*R. A. Dyke.*

### DENVER FORECAST DISTRICT

The first half of the month was marked by great barometric activity and consequent unsettled weather conditions and decided temperature fluctuations. The outstanding feature was the almost unprecedented stormy weather that continued for a week or more in Arizona attending a LOW that entered California on the second of the month and remained over the southwest with varying intensity and in varying geographic positions until the morning of the 11th, when it finally disappeared, seemingly either filling up or drifting into old Mexico. This disturbance brought the heaviest December rains of record to southwestern Arizona, the total amount at Yuma, 4.43 inches, being nearly nine times the normal for December and one inch more than the normal amount for an entire year. A disturbance of great intensity appeared in northern Alberta on the evening of the 10th and took a course almost due south, reaching eastern Colorado by the morning of the 12th. This storm was succeeded by the rapid spread of high pressure, accompanied by severely cold weather, over the northwestern States. This HIGH continued over the northern part of the district until the 17th. Thereafter a series of disturbances moved eastward along the Canadian border, while several HIGHS entered and disappeared in the Plateau region until finally one formed that persisted during the closing days of December and well into January. These latter changes in pressure were attended by comparatively settled weather conditions during the latter half of the month.

Cold-wave warnings were issued the evening of the 11th for eastern Montana and northern Wyoming, and the morning of the 12th for southern Wyoming, eastern Colorado, and eastern New Mexico, livestock interests being notified in southern Wyoming and eastern Colorado. These warnings were timely and were fully justified except in New Mexico where the fall in temperature was too gradual for technical verification. On the 22d warning was issued for a moderate cold wave in eastern and southern Montana, eastern and southern Wyoming, and northeastern Colorado. While not fully verifying over the entire region specified, the temperature drop ranged from 16 to 24 degrees, with minimum readings from 16 degrees above to 4 degrees below zero. A warning the evening of the 25th of a moderate cold wave in northeastern Montana was fully verified in the extreme northeastern part of the State. Numerous advices of expected fresh to strong winds in southern Wyoming and eastern Colorado were issued for the benefit of the air mail services, most of them being well verified. Frequent frost or freezing temperature warnings were issued for southern Arizona, as were also the usual weekly advices of expected temperature conditions to the northwestern fruit shippers, supplemented by special advices in advance of the cold waves in Montana and Wyoming.—*E. B. Gittings, jr.*

### SAN FRANCISCO FORECAST DISTRICT

At the beginning of December the pressure was relatively low over all parts of the northeast Pacific Ocean, with a disturbance on the coast of Washington which required the continuance of storm warnings that had been ordered along the north coast on the last day of the previous month, and their extension to include all Puget Sound ports. Gales occurred along the coast during the afternoon of the 1st and on the Sound the following night, unusual velocities being recorded. At North Head the wind reached a velocity of 94 miles an hour and at Seattle 60 miles. Thereafter for several days the barometer rose over the ocean between our coast and Hawaii with the major axis of the HIGH lying in a general northeast-southwest direction. Several disturbances generated under this HIGH—that is to say, on its southeastern border, their direction of travel being governed by the main air currents along the periphery of the HIGH. The first formed off the northern California coast on the 2d, the next over the southern Plateau on the 6th, and the 3d over southern California on the 8th. Warnings were required on some part of the California coast for both the latter depressions, and northerly gales prevailed over the ocean on both dates, but were most severe on the 8th.

On the 10th a radical change in type took place, the major axis of the oceanic HIGH shifting to a northwest-southeast direction with a marked rise in pressure over high latitudes in midocean. This attitude of the Pacific HIGH, although modified at intervals, recurred presistently until the 26th of December, and the phenomena which attended it corroborated to a remarkable degree the views which had been entertained in the district forecast office regarding the connection between this lie of the isobars and concurrent pressure developments in the far Western States. In particular, it has been found that (1) when the major axis of the oceanic HIGH is as described, disturbances lodged in the air currents on the polar side of the HIGH travel in a south or southeastward direction,

or if they move eastward leave vigorous secondaries over the lower latitudes, and (2) that when the axis of the oceanic HIGH assumes the direction above described, if a Plateau HIGH exists at the same time it will disappear or be greatly vitiated in from 12 to 36 hours, no matter how intense it may appear to be. For instance, on the 10th the reduced pressure at Winnemucca was 30.52 inches. Twenty-four hours later a disturbance which had been centered near Cordova, Alaska, was over central Canada and the pressure at Winnemucca had fallen to 30.04 inches, while within another 24-hour period an independent LOW was located over Utah and rain had fallen in the Pacific Forecast District as far south as the Mexican border.

These incidents were, in a general way, repeated in the series of charts beginning on December 20th when, with a LOW centered over southeastern Alaska, a HIGH over Nevada rapidly disappeared, the pressure at Winnemucca falling from 30.24 inches on the date in question to 29.62 inches 24 hours later, and precipitation covering the Pacific States from the northern to the southern border within the same period. During the inclusive period mentioned, numerous storm warning displays were made on the north coast and occasionally over Puget Sound, namely, on the 10th, when warnings were ordered for the Washington coast, on the 14th for all points in Oregon and Washington, on the 17th for the northern California coast and on the 20th and 23d for all Washington and Oregon stations. In all cases the warnings were justified by subsequent winds in some part of the area specified, except in the case of those on the 14th which were attended by an anomalous absence of gale phenomena, considering the fact that pressure developments took place about as expected.

On the 26th a reversion to the southwest-northeast type of isobar occurred in the oceanic HIGH, which was immediately followed by the accumulation of high pressure over the Plateau and Rocky Mountain region and which persisted until the close of the month. Gale warnings were displayed on the 26th, 27th, 29th, 30th, and 31st for northern ports, all of which were followed by stong winds or gales in some part of the area affected.

The storm referred to as moving southeastward from Alaska on the 10th was followed by a southeastward movement of a great body of high pressure from polar regions which reached the North Pacific States on the 13th, requiring cold-wave warnings for eastern Washington and northern Idaho on the 12th. Advices of the approach of a general cold period were also sent to other parts of the forecast district which it was known would be affected, and the public was adequately forewarned.

Frequent frosts characterized the month in California and general warnings were issued for all or parts of that State on 19 dates. The most noteworthy were those which were followed by more or less general firing in the citrus districts on the 25th, 27th, 28th, and 29th.—*T. R. Reed.*

## RIVERS AND FLOODS



By H. C. FRANKENFIELD

The outstanding features of river regime during the month were the general and disastrous floods in the Southern streams tributary to the Ohio River, an unprecedented occurrence within the last 54 years. Only twice within this period (the floods of 1926 excluded), has the flood stage in the Upper Tennessee River been exceeded by a significant amount (39.5 feet at Chattanooga, Tenn., on December 31, 1901, and 34.4 feet on December 21, 1915). The lower Tennessee and the Cumberland Rivers have been entirely free from floods of consequence.

*Cumberland River.*—A period of moderate to heavy rains from December 8 to 13 was attended by marked rises in the rivers, and before the usual decline could be accomplished, another period of excessive rains came on (December 20 and 21), and a second and much more rapid rise set in. Over the drainage area of the Cumberland River, the average rainfall was a little over 4.25 inches, and flood warnings were indicated at once. Thus far creast stages only a few feet above the flood stages were indicated; in other words, moderately high floods only. Unfortunately, on December 24, another two-day heavy rain period began (average about 3.50 inches), and, as a matter of course, the flood conditions became greatly intensified. On December 25 additional warnings were issued for further rises of about 8 feet in a river already above flood stage. These second warnings were closely verified as to stage and time, and would have marked the crests of the flood had not another rain of about 1.50 inches fallen on December 27 and 28. Again more water was indicated and again warnings were revised to meet a situation that was already most grave, dangerous, and destructive. Not more than a foot or two of additional rise could occur above Nashville, but at and below that city a further increase of 3 or 4 feet was inevitable.

The table at the end of this report shows the crest stages reached. As a whole, the flood will rank in importance with that of January, 1882. The flood of 1926 was greater between Carthage and Nashville, Tenn., and may finally be determined to be greater in its entirety. This will be determined by a resurvey of several high-water marks of 1882.

Flood damage was most serious between Carthage and Nashville, and reliable estimates of its extent were unobtainable. Many persons, of the opinion that a repetition of the flood of 1882 was impossible, and especially at this time of the year, had done considerable building and had stored valuable property within the range of the flood waters to such an extent that it could not be moved within a reasonable time. Moreover, it was reported that much loss was due to the fact that many persons failed to heed the warnings for abnormally high water. It must be admitted also that considerable loss was occasioned through the fact that the earlier forecasts were not sufficiently broad. This can hardly be termed a failure of commission, as the coming of additional heavy rains added complications that could not be foreseen at the time the forecasts were made.

Two lives were lost during the flood, both in Nashville. Very incomplete reports of loss and damage are as follows:

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|---|---|
| (1) Tangible property | $454,342 |
| (2) Crops | 441,300 |
| (3) Livestock | 68,300 |
| (4) Suspension of business, etc | 113,135 |
| Total | 1,077,077 |

Other estimates exceeded this total, the Nashville Banner estimating the losses in Nashville and vicinity alone at $1,500,000. The reported value of property saved through the warnings of the Weather Bureau was $1,207,850.

Newspaper reports indicate that at least 5,000 people in Nashville and 4,000 in other places were forced to abandon their homes. Much of the city of Nashville, especially East Nashville was under water, and at one